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Parental worry about indoor air quality and student symptom reporting in primary schools with or without indoor air quality problems

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ABSTRACT

Poor indoor air quality (IAQ) in schools is related to increased symptom reporting in students. We investigated whether parental worry about school IAQ influences this association. Data came from survey collected from five Finnish primary schools with observed IAQ problems and five control schools. Parents (n=1868) of primary school students reported worry about IAQ in schools and symptoms of their children. Associations between observed IAQ problems, worry, and five symptom scores (i.e., respiratory, lower respiratory, eye, skin, and general symptoms) were analyzed using multivariate logistic regression and mediation analysis. Parents were on average more worried in schools with observed IAQ problems. Observed IAQ problems were strongly associated with increased worry and all symptoms under study (unadjusted ORs ranged between 1.48 [95% CI 1.48–2.16], and 2.70 [95% CI 1.52–5.17]). Parental worry was associated with all symptoms (unadjusted ORs ranged between 2.49 [95% CI 1.75–3.60], and 4.92 [95% CI 2.77–9.40]). Mediation analyses suggested that parental worry might partially explain the association between observed IAQ problems and symptom reporting (proportion mediated ranged between 67% and 84% for the different symptoms). However, prospective studies are needed to assess causal relationships between observed IAQ problems, worry, and symptom reporting in schools.

Keywords (6): indoor air quality, respiratory symptoms, worry, primary school, concern, psychosocial

Practical implications. Parental worry may play a major role in some school IAQ problems in Finland through its potential to increase symptom reporting. Indoor air questionnaires are a valuable source of information for IAQ problem management, but their results need to be interpreted with caution when there is a high level of worry among the respondents. Renovations should always be based on adequate building and structural inspections.

INTRODUCTION

Previous research has repeatedly shown that perceived health and symptom reporting of those exposed to indoor air quality (IAQ) problems is associated with both physical and psychosocial characteristics of indoor environment. Moisture or mould damage in buildings is related to higher levels of symptom complains of the occupants, although the causal relationships are still not established[1–3]. This association has also been shown in school environment[4–6].

Self-administered questionnaires are widely used to collect information about perceived IAQ in schools and related symptoms. Such data may, however, be biased due to various psychosocial factors[7]. School IAQ problems are common in Finland[8], and they are recognized as a serious threat to children's health and well-being, increasing the level of worry among parents and causing considerable concern. Given that parents of primary school students usually report symptoms for their children, the role of *parental* worry in the development of symptom complains should be taken into account when designing questionnaires and making interpretations based on the questionnaire data.

The role of psychosocial factors in the development of health complains has been widely studied in the context of office workers and sick building syndrome[9,10]. In a recent longitudinal study in the school environment, socioemotional difficulties were associated with increased reporting of symptoms related to indoor air[11]. Evidence from experimental studies also supports the potential role of psychological mechanisms, such as attention and expectations, in symptom reporting in general[12–14]. This multifactorial origin of symptom reporting during IAQ problems complicates the designing and interpretation of IAQ questionnaires, as well as problem management.

Health-related worry is one of the psychosocial factors related to IAQ problems, which seems to play a role in the development of symptom complaints. For example, higher levels of worry about health risks of environmental hazards have been shown to be associated with a higher number of symptoms[15–17]. In addition, health worries were suggested to play a role in the attribution of symptoms and beliefs about health effects after environmental incidents[18]. In relation to indoor air quality, a previous study conducted in office settings has shown that health-related worry is associated with increased symptom complains[19]. Although health-related worry seems to play a role in the development of symptoms, this issue has not been assessed in the context of school IAQ problems.

Indirect evidence, therefore, suggests that worry about IAQ problems could act as an intermediate variable explaining part of the association between observed IAQ problems and symptom reporting. This is supported by a study suggesting that air pollution at non-toxic levels indirectly influenced health symptoms through subjective perceptions (including worry) about the effects of pollution[20]. Another recent study suggests that appraisal of office environmental stressors, such as dust, noise and glare, mediates the relationship between these characteristics and health symptoms[21]. Based on the previous literature it, therefore,

seems plausible to assume that worry could partly explain the association between observed IAQ problems and symptom reporting also in the school environment.

Drawing on cross-sectional IAQ questionnaire data collected from parents of Finnish primary school students, the present study examined the role of parental worry in symptom reporting of their children in schools with and without observed indoor air quality problems. The first aim of this study is to explore how common parental IAQ related worry is in schools with IAQ problems compared to schools without IAQ problems. Another goal is to examine the role of worry in the association between IAQ problem and symptom reporting (Figure 1, model 1.1).

METHODS

Data collection

Data for the study was collected in ten primary schools in five municipalities in Finland between March 17 and April 4 in 2014. All 71 regional environmental health units in Finland were approached via e-mail, asking for willingness to participate in the study and for suggestions on schools with current, observed indoor air problems (i.e., "case schools") and control schools without indoor air problems in the same municipality. They were requested to include basic information on the schools (name, address, contact, and number of pupils) and a short description of the schools' status regarding indoor air problems.

Of twelve schools suggested by the regional environmental health units, five schools with current indoor air problems (i.e. case schools) and five schools without such problems (i.e. control schools) were selected for the study[22]. In all of the case schools there were extensive symptom reports from the personnel. Information about the nature of the observed IAQ

problem was available for only two out of five case schools, which both had suffered mold and dampness damages (Table S5).[22] The severity of the observed IAQ problems was not described in any of the case schools. The control schools had no observed indoor air quality problems (e.g., no observations or reports of indoor-related problems based on the description of schools' status by environmental health or other officials of the municipality). The parents were not informed if their child was studying in case or control school. However, the parental awareness of observed indoor air problem was measured. More details of the data collection are given elsewhere[22].

Printed questionnaires were sent to all parents of primary school students in case and control schools (i.e., students were from first to sixth grade, typically between 7 to 12 years of age). The parents were instructed to fill in the questionnaire on symptoms together with the child. Overall, 83% (n=2275) of the parents returned the questionnaire. The majority of the respondents were mothers (79%, n=1797), and 76% (n=1720) of all respondents reported filling in the questionnaires together with the child. The current analyses included 1868 respondents (of which 80.2%, n=1498, were mothers and 9.3%, n=174 were fathers) with complete data on all the variables of interest. The mean age of primary students was 9.83 (SD=1.77), ranging from 7 to 13 years.

Measures

The questionnaire used has been described in more detail in an earlier paper[22]. Shortly, the questionnaire included 18 questions on symptoms experienced by the child during the last four weeks with the response format "never" = 0, "sometimes" = 1, "every week" = 2, and "almost every day" = 3. The symptoms were selected based on previous indoor air questionnaires used in schools in Finland and Sweden (MM-80).[22] Based on the results of our previous study[22], five symptom scores were used in this study: respiratory (runny nose, stuffy

nose, cough, hoarseness, and sore throat), lower respiratory (nocturnal cough, shortness of breath, wheezing), eye (itchy eyes and watery eyes), skin (itchy skin and rash), and general symptoms (fatigue, concentration difficulties, and headache). Single symptom items were first dichotomized (every week or almost every day = 1, never or sometimes = 0). The binary symptom score was considered positive, if a child experienced at least one of the symptoms included in the definition of the symptom score, i.e. a child was given a value of "1" for the respiratory score if he or she experienced at least one of the following symptoms (runny nose, stuffy nose, cough, hoarseness, or sore throat). The dichotomized symptom scores have been shown to capture well the diversity of symptoms and express the differences in symptom prevalence between schools[22].

Parental worry about IAQ in schools was measured using the question "How worried are you about the quality of indoor air in your child's school?" The item was asked on a 5-point Likert-type scale where "1" means no worries at all about IAQ problems and "5" means a lot of worries about IAQ problems. Worry was used as dichotomized variable in the analysis (worried a lot, quite a lot, or to some extent = 1, otherwise = 0). The analyses were also repeated with different classification of worry (worried a lot or quite a lot = 1, otherwise = 0), and the obtained results were very similar to the findings presented.

Parental awareness about observed IAQ problem in the school was measured by a question; "Is there an observed indoor air problem caused by mold or dampness in your child's school?" with the response format "yes", "no" or "not sure". Awareness was used as dichotomized variable in the analysis (yes = 1, otherwise = 0).

The questionnaire form included the questions described in the following order: respiratory symptoms and other symptoms (i.e., lower respiratory, eye, skin, and general symptoms), worry about school IAQ, and awareness about observed IAQ problem in the school.

Schools with observed IAQ problems (i.e., case schools; schools with observed mold or dampness damages or extensive symptom reports from personnel) were coded as "1" and schools without such problems (i.e., control schools) were coded as "0" to create one variable reflecting the observed IAQ problems in schools.

Potential confounders

We controlled for students' age, sex, parental smoking (1 = mother, father or other person in household smokes, 0 = no one smokes), respondent who filled in the questionnaire (1 = mother, 0 = other) in the analysis. We also controlled for students' previous allergic diseases, which included asthma, hay fever, and atopic eczema experienced during the last 12 months (1 = yes, 0 = no) and infection, which included bronchitis, sinusitis, and otitis experienced at least once during the previous 12 months (1 = yes, 0 = no). We also controlled for the socioeconomic status of the students' family measured by mother's level of education (comprehensive school = 1, high school or vocational school = 2, bachelor's degree = 3, master's degree = 4).

Statistical analysis

The associations between observed IAQ problem, worry, and symptom scores were estimated using multivariate logistic regression models adjusting for all the covariates described above. Additional models were adjusted also for worry, and proportion mediated by worry was estimated by calculating the change in odds ratio (excess risk) after adjusting for worry. The analyses were conducted separately for each symptom score (i.e., respiratory, lower respiratory, eye, skin, and general symptoms).

The potential mediating role of worry in the association between observed IAQ problems and symptom reporting (Figure 1, model 1.1) was then further examined using the mediation analysis for binary outcome and mediator[23]. An indirect effect was calculated as a product of the paths going through the mediator. Because the present study is cross-sectional, we also examined the possibility that observed IAQ problems may influence worry through symptom reporting. Therefore, we also estimated the alternative model (Figure 1, model 1.2) where symptom scores were used as potential mediators in the association between observed IAQ problem (i.e., exposure) and worry (i.e., outcome).

A p-value of 0.05 was considered statistically significant in a two-tailed test. Cross tabulation and logistic regression analysis were performed using R (version 3.4.1) and the following packages: sandwich, foreign, and plyr. Mediation analysis was performed using *paramed* command in STATA (version 15)[24].

RESULTS

In general, more parents were worried about indoor air quality in case schools than in control schools (Table 1). In all of the control schools, the number of worried parents was relatively low although there were differences between schools (10% – 22%) (Figure 2). In schools with observed IAQ problems, the number of worried parents was higher, and the level of worry differed greatly between schools (55% – 89%). The prevalence of respiratory, lower respiratory, eye, skin and general symptoms was higher in case schools than in control schools (Table 1). The prevalence of respiratory symptoms differed between control schools (4% – 11%) and between case schools (11 – 25%) (Figure 2). The differences between schools in prevalence of lower respiratory, eye, skin, and general symptoms were similar to the prevalence of respiratory symptoms (data not shown). Asthma was more common in case

schools than in control schools, whereas sinusitis was less common in case schools. Bronchitis, otitis, atopic eczema, hay fever, as well as student's sex, respondent's sex, mother's high level of education, and parental smoking did not differ statistically significantly between the case and control schools.

More than half of parents in case schools were aware of the observed IAQ-problems in their children's school (56%, n=681), 32% (n=384) were not sure and 11.8% (n=142) replied that there were no such problems. In control schools, 3.4% (n=23) claimed that there were observed IAQ-problems in their children's school, 53% (n=350) were not sure and 43.6% (n=288) replied that there were no such problems. Parental awareness of the observed IAQ-problem differed greatly between case schools (28.8%–92.4%). In control schools, parental awareness did not differ much between four schools (0.0%-1.3%), whereas in one school it was higher (10.3%). Parental awareness was also associated with both parental worry (Figure S1) and prevalence of respiratory symptom (Figure S2) in case schools.

Worried parents were more likely to report their children to be suffering from any of the symptoms under study than parents who were not worried (Table 2). Asthma, atopic eczema, hay fever, bronchitis, sinusitis and otitis were reported more by the worried parents. Worried parents were less likely to be smokers than parents who were not worried. Mothers were more likely to be worried than other respondents, but the sex of the respondent was not associated with reporting of any of the symptoms or covariates. Student's sex and mother's level of education did not differ statistically significantly between worried and not worried parents.

Observed IAQ problems were associated with all symptom scores (OR ranged between 1.56, with 95% Confidence Interval [CI] of 1.02–2.42, to 2.52, 95% CI: 1.37–4.99) after adjustment for all confounders (Table 3). These associations were strongly reduced and

became non-significant for all symptom scores, except general symptoms after further adjustment for worry (Table 3). The crude, unadjusted odds ratios describing the association between observed IAQ problem and symptom reporting, as well as the association between observed IAQ problem and worry are presented in Tables S3 and S4, respectively. The associations remained essentially similar when adjusted for the covariates.

The interaction term between observed IAQ problems and worry on symptom reporting was tested in all models and found to be non-significant. The proportion of the association between observed IAQ problem and symptom reporting mediated by worry ranged between 64% and 85% when estimated by using logistic regression analysis (Table 5).

The results of the mediation analysis suggest that the association between observed IAQ problems and reporting of symptoms is partially mediated by worry (Table S1). The indirect effect of observed IAQ problem on symptom reporting through worry was statistically significant for all symptoms. The ORs describing the indirect effect ranged between 1.42 (95% CI: 1.05–1.89) and 2.02 (95% CI: 1.26–3.07). The estimated direct effect was significant for general symptoms, and non-significant for respiratory, lower respiratory, eye, and skin symptoms. The estimated total effect was significant for all the symptoms. The proportion of the association between observed IAQ problem and symptom reporting mediated by worry ranged between 67% and 84% when estimated by using mediation analysis (Table 5). These results were similar to results estimated by logistic regression.

Logistic regression and mediation analysis were repeated in an alternative model describing the association between observed IAQ problems and worry mediated by symptom reporting (Figure 1, model 1.2). The odds ratios describing the association between observed IAQ problems and worry were slightly reduced when adjusting for symptom reporting (Table 4). The indirect effects of observed IAQ problems on worry through symptom reporting were

significant for respiratory, eye, and general symptoms, but they were small (Table S2). The indirect effects were non-significant for lower respiratory and skin symptoms. The total effects were significant for all of the symptoms. The interaction terms between observed IAQ problems and symptom reporting on worry were tested in all models and found to be non-significant. The proportion of the association between observed IAQ problem and worry mediated by symptoms estimated by both logistic regression and mediation analysis was small (Table 5).

DISCUSSION

The aims of this study were to explore the prevalence of worry in primary schools with observed IAQ problems compared to those without such problems and to evaluate the associations between worry, symptom reporting, and observed school IAQ problems. We found that parental worry about IAQ problems can be common in schools with observed IAQ problems, although the level of worry differs between schools. Moreover, parental awareness about the observed IAQ problem also differs greatly, but only between schools with observed IAQ problems. We also found that parental worry is strongly associated both with students' symptoms and with observed IAQ problems. Parental worry may in some schools partially explain the association between indoor air quality-problems and symptom reporting; however, we consider these findings preliminary because of the cross-sectional data used.

Our findings of increased symptom reporting in schools with observed IAQ problems are in line with the findings of previous studies[4–6], and provide new evidence on lower respiratory, eye, skin, and general symptoms. However, we also found that the levels of symptom reporting can differ greatly between case schools. Although the evidence available is not sufficient to confirm dose-response associations between mold or dampness exposure and

adverse health effects[25,26], it is possible that the severity and the nature of the observed IAQ problem could explain some of the differences in the prevalence of symptoms between schools. Research on the causal reasons contributing to development of building-related symptoms is needed to better understand the differences between case schools in symptom reporting.

Furthermore, we found that worried parents report more symptoms for their children than parents who were not worried. To our knowledge, this is the first study to suggest the associations between parental IAQ related worry and symptom reporting in the context of school IAQ problems, and several studies from slightly different contexts support our findings[15–17,19,27].

Parental worry can be common in some schools with observed IAQ problems, although the level of worry seems to differ greatly between schools. High levels of worry are previously reported in office workers exposed to IAQ problems[28], but this is the first study to assess the levels of worry in context of school IAQ problems. There are probably differences in the problem management procedures that might explain some of the differences in the levels of worry. For example, in some schools the observed problems might be discussed more extensively, which increased parental awareness about the problems. Awareness about potential health risks, in turn, can subsequently lead to increased worry; especially, if the communication about the problems is unnecessarily saturated with warnings about the adverse health effects of the exposure[29]. Furthermore, characteristics of adequate problem management, like providing open and coherent information, refraining from use of jargon and taking concerns of the parents seriously, might not be equally present in the schools with IAQ problems, further promoting development of worries. The level of worry might also depend on the nature of the observed IAQ problem. The school personnel, health care

professionals and officials responsible for IAQ problem management need to be aware of possible increased worry among the parents and communicate with them in a way that might reduce the unnecessary worry. Therefore, the level of worry should be assessed in schools with IAQ problems.

Our findings from mediation analysis suggest that worry might act as a potential mediator and partially explain the relationship between IAQ problems and symptoms. These results are supported by several previous studies suggesting that environmental hazards and stressors are associated indirectly with increased symptom complaints[20,21]. We cannot, however, eliminate the possibility that symptoms might also act as mediators of the association between IAQ problems and worry because this study is based on cross-sectional data. Even though our results show stronger associations in the pathway from IAQ problems to symptoms through worry, it should be kept in mind that these two pathways are not mutually exclusive but coexist. Further prospective studies are needed to assess the causal relationships between IAQ problems in schools, worry, and symptom reporting.

Worries about potential health threats, amongst numerous other psychosocial factors, may change the way people perceive and interpret somatic information. This is partly because worries create symptom expectations and cause selective attention to bodily processes, whereby people are more likely to notice common physiological sensations and symptoms and attribute them to health threats[30]. Experimental research further supports the role of cognitive processes, including worry, in symptom reporting. In a series of experimental studies, it has been shown that participants who received negative information about an odor stimulus reported more respiratory or other symptoms than participants who received positive information about it [31–33]. Also, healthy volunteers informed about the expected physiological effect of the exposure reported more symptoms in comparison to uninformed volunteers who

reported no symptoms after exposure[34]. In addition to cognitive processes, the perception and interpretation of somatic information can be influenced by psychological states. For example, highly distressed participants tend to perceive the exposure as more unpleasant and report more symptoms compared to less distressed participants, especially after receiving negatively biased information about the exposure.[35]

Questionnaires for primary school aged children have traditionally been parent-administered. However, we have previously shown that self-administered questionnaires to the children themselves may yield as good, if not better, information[36]. Administering questionnaires to children also leads to better response rates. It is also possible that the effect of worry to reported symptoms in child-administered questionnaires may not be so strong. The possibility to use self-administered questionnaires to collect information about symptoms from the school children themselves should be studied further and the influence of worry on self-reported symptoms assessed.

To date, the officials responsible for problem management lack good quantitative methods to guide the health risk assessment related to especially mold and moisture damage and visual or olfactory observations of dampness or mold is typically used.[25,26,37] However, no threshold levels indicating unhealthy levels of dampness or moisture have been determined.[25] Data concerning perceived symptoms collected by self-administered questions, despite the limitations discussed in this paper, still remain an important tool in problem management at least in Finland, but renovations should be based on adequate structural inspections.

This study has several limitations which should be taken into account while interpreting the results. First, the study was based on cross-sectional data, thus no claims about causality can be made, reverse causality cannot be ruled out and the results of the mediation analysis need to be interpreted with caution. Second, most of the respondents were mothers, thus the

findings of this study might not be applicable to fathers. Third, although the parents were instructed to fill in the questionnaires together with the child, the questionnaires were parent-administered, and the results do not necessarily reflect the perceived symptoms of the children themselves. Fourth, data on the nature and severity of the school IAQ problems was limited and there were no objective measurements of IAQ available. Fifth, due to the method used to select the small number of schools included in the present study, the present results may not be typical or generalizable to all schools with IAQ problems in Finland. Sixth, the order of questions in the questionnaire could possibly affect the results: given that the questions concerning the symptoms were inquired before the level of worry, they could have influenced the responses to questions about worry.

In sum, this study shows that high levels of parental worry are strongly associated with both IAQ problems in schools and students' symptom reporting. Parents who were worried about school IAQ reported their children having symptoms more often than parents who were not worried. This study also provides evidence that parental worry might partially explain the association between IAQ problems and symptom reporting. The findings of this study suggest that parental worry may play a major role in some school IAQ problems in Finland through its potential to increase symptom reporting. However, prospective studies are needed to assess the causal relationships between observed IAQ problems, worry, and symptom reporting in schools. Indoor air questionnaires are a valuable source of information for IAQ problem management, but their results need to be interpreted with caution when there is a high level of worry among the respondents.

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Table 1. Prevalence of worry about indoor air quality, symptoms and covariates in case and control schools.

	Control (n=661)		Case (n=1207)				
	n	**%**	**n**	**%**	**OR**	**95% CI**	**p**
Worry about school IAQ	103	15.6	842	69.8	12.50	9.84 - 16.01	***
Respiratory symptoms	54	8.2	199	16.5	2.22	1.63 - 3.07	***
Lower respiratory symptoms	13	2.0	62	5.1	2.70	1.52 - 5.17	**
Eye symptoms	39	5.9	144	11.9	2.16	1.51 - 3.16	***
Skin symptoms	42	6.3	110	9.1	1.48	1.03 - 2.16	*
General symptoms	105	15.9	333	27.6	2.02	1.59 - 2.58	***
Child's sex	352	53.2	594	49.2	0.85	0.70 - 1.03	0.095
Asthma	29	4.4	103	8.5	2.03	1.35 - 3.16	**
Atopic eczema	150	22.7	305	25.3	1.15	0.92 - 1.44	0.215
Hayfever	115	17.4	245	20.3	1.21	0.95 - 1.55	0.129
Bronchitis	45	6.8	88	7.3	1.08	0.75 - 1.57	0.698
Sinusitis	72	10.9	88	7.3	0.64	0.46 - 0.89	**
Otitis	74	11.2	166	13.8	1.26	0.95 - 1.70	0.115
Mother’s high level of education	285	43.1	536	44.4	1.05	0.87 - 1.28	0.591
Parental smoking	197	29.8	328	27.2	0.88	0.71 - 1.08	0.227
Respondent mother	528	79.9	970	80.4	1.03	0.81 - 1.30	0.801

OR = unadjusted odds ratio

CI = confidence interval

Table 2. Prevalence of symptoms and covariates by the level of parental worry about school IAQ.

	Not worried (n=923)		Worried (n=945)				
	n	**%**	**n**	**%**	**OR**	**95% CI**	**p**
Respiratory symptoms	56	6.1	197	20.9	4.08	3.00 - 5.62	***
Lower respiratory symptoms	13	1.4	62	6.6	4.92	2.77 - 9.40	***
Eye symptoms	43	4.7	140	14.8	3.56	2.52 - 5.13	***
Skin symptoms	45	4.9	107	11.3	2.49	1.75 - 3.60	***
General symptoms	135	14.6	303	32.1	2.75	2.20 - 3.47	***
Child's sex	461	50.0	485	51.3	1.06	0.88 - 1.27	0.552
Asthma	44	4.8	88	9.3	2.05	1.42 - 3.00	***
Atopic eczema	181	19.6	274	29.0	1.67	1.35 - 2.08	***
Hay fever	151	16.4	209	22.1	1.45	1.15 - 1.83	**
Bronchitis	38	4.1	95	10.1	2.60	1.78 - 3.88	***
Sinusitis	56	6.1	104	11.0	1.91	1.37 - 2.70	***
Otitis	104	11.3	136	14.4	1.32	1.01 - 1.74	*
Mother’s high level of education	387	41.9	434	45.9	1.18	0.98 - 1.41	0.082
Parental smoking	293	31.7	232	24.6	0.70	0.57 - 0.86	**
Respondent mother	718	77.8	780	82.5	1.35	1.07 - 1.70	*

OR = odds ratio

CI = confidence interval

Table 3. Adjusted odds ratios (OR) for the association between observed IAQ problems in schools and reporting of child's symptoms without and with adjustment for parental worry about IAQ in the school (model in Figure 1.1).

	Multivariate adjusted*		Adjusted in addition for worry**	
	OR	**95% CI**	**OR**	**95% CI**
Respiratory symptoms	2.31	1.66 - 3.27	1.19	0.80 - 1.79
Lower respiratory symptoms	2.52	1.37 - 4.99	1.24	0.60 - 2.70
Eye symptoms	2.27	1.55 - 3.38	1.29	0.83 - 2.06
Skin symptoms	1.56	1.02 - 2.42	1.08	0.65 - 1.83
General symptoms	2.12	1.65 - 2.75	1.40	1.04 - 1.90

*** adjusted for students' age, sex, previous allergic diseases and infections, mother's level of education, parental smoking, and the respondent of the questionnaire.**

**** adjusted for the above covariates and parental worry about IAQ in the school.**

Table 4. Adjusted odds ratios (OR) for the association between observed IAQ problems in schools and parental worry without and with adjustment for symptom reporting (model in Figure 1.2).

Multivariate adjusted*		Adjusted in addition for following symptoms**		
OR	**95% CI**		**OR**	**95% CI**
15.95	12.25 - 20.99	Respiratory symptoms	15.60	11.95 - 20.59
		Lower respiratory symptoms	15.73	12.08 - 20.71
		Eye symptoms	15.66	12.01 - 20.65
		Skin symptoms	15.89	12.20 - 20.92
		General symptoms	15.26	11.70 - 20.11

*** adjusted for students' age, sex, previous allergic diseases and infections, mother's level of education, parental smoking, and the respondent of the questionnaire.**

**** adjusted for the above covariates and symptom reporting.**

Table 5. Proportions mediated for two alterative models describing the interrelations between IAQ problem, worry and symptom reporting (models in Figures 1.1 and 1.2) estimated by logistic regression and mediation analysis.

	IAQ Problem –> Worry –> Symptom		IAQ Problem –> Symptom –> Worry	
	Logistic regression	**Mediation analysis**	**Logistic regression**	**Mediation analysis**
Respiratory symptoms	85 %	84 %	2 %	13 %
Lower respiratory symptoms	84 %	82 %	2 %	5 %
Eye symptoms	77 %	77 %	2 %	8 %
Skin symptoms	85 %	82 %	0 %	1 %
General symptoms	64 %	67 %	5 %	11 %

Figure 1. Two alternative causal models describing the interrelations between IAQ problem, worry and symptom reporting.

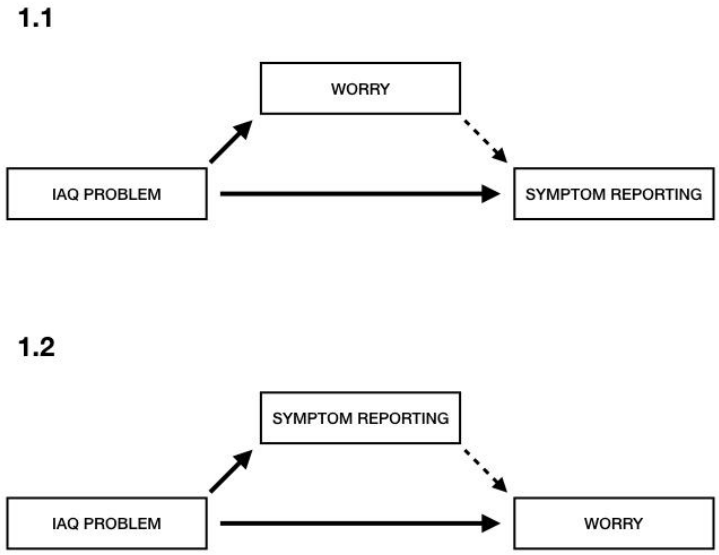

Figure 2. Association between parental worry about school IAQ and respiratory symptom reporting in schools with and without observed indoor air problems.